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Basic Characteristics of the Geological History of Tuva

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Figure 1. The effect of the concentration of the *Agrobacterium* suspension on the transformation efficiency of *Agrobacterium* strains. The *Agrobacterium* strains were incubated with the plant explants for 24 h. The explants were then cultured on the selective medium. The number of explants transformed was counted. The results are the mean $\pm$ SD of three independent experiments. * indicates significant difference ($p < 0.05$) between the control and the treatment.

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1. *Psychological* 2. *Physical* 3. *Chemical* 4. *Biological* 5. *Environmental* 6. *Social* 7. *Political* 8. *Economic* 9. *Cultural* 10. *Religious* 11. *Philosophical* 12. *Artistic* 13. *Scientific* 14. *Medical* 15. *Legal* 16. *Historical* 17. *Geographical* 18. *Archaeological* 19. *Literary* 20. *Mathematical* 21. *Statistical* 22. *Computational* 23. *Engineering* 24. *Technology* 25. *Information Science* 26. *Communication* 27. *Management* 28. *Business* 29. *Finance* 30. *Marketing* 31. *Operations* 32. *Human Resources* 33. *Project Management* 34. *Quality Management* 35. *Supply Chain Management* 36. *Logistics* 37. *Transportation* 38. *Infrastructure* 39. *Urban Planning* 40. *Public Administration* 41. *Public Health* 42. *Environmental Health* 43. *Occupational Health* 44. *Healthcare* 45. *Medicine* 46. *Nursing* 47. *Pharmacy* 48. *Dentistry* 49. *Veterinary Medicine* 50. *Biotechnology* 51. *Genetics* 52. *Immunology* 53. *Microbiology* 54. *Plant Biology* 55. 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The eastern part of Tuva was characterized by its tendency to rise and it reacted to all succeeding tectonic stresses by breaking. The development of the western and

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[illegible]

The study of the tectonic conditions in Tuva was begun in 1941 by L. M. Kozlovskiy in the region of Lake Baikal. Small-scale geological maps were published. Kozlovskiy, from 1942 to 1944, worked [13] in the Tannu-Ola Mountains, from which in 1944 we received confidential descriptions of the Permian and Triassic. In 1944 we discovered confidential descriptions of the Permian (4) and in the first published (divided) of the rivers Tannu-Ola and Chag-Elabring; that is, within the boundaries of the western tectonic zone, Ordovician Triassic deposits are unknown in Tuva; possibly later on, a part of the Permian deposits will be related to the Triassic. Jurassic deposits in general form the conspicuous spots, related to the big contemporary valleys of Tuva, the Ili-Khesok and the southern boundary of Todorzhin [14]. Tertiary deposits were developed in small spots on the southern edge of the Tannu-Ola Mountain Chain [15].

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The third "structural floor" is distinguished by a sharp change of folding. Successive folds lying on the Devonian-Cambrian boundary layer, as far as the Siberian inclusive, form steep folds of large radius, which pass smoothly into horizontal layers; the spots of intensive deformations are coordinated to zones of disjunctive disturbances and usually are strictly parallel. The dislocations of tertiary deposits are closely related to thick fractures that separate the horst (fault ridge) of the Tannu-Ola Mountain Chain from the south.

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originate in consequence of differential vertical shifts of individual rocks of the cracked solid base. A distinguishing peculiarity of the folds considered is the predominance of undisturbed shapes of the brachy-fold type and a sharp difference in size depending on the depth of the deposits: in the central part of basins where the thickness is greater, the folds are bigger and slanting and, on the margins they are smaller and steeper. Independently of thickness of the deposits and location, the presence of relatively narrow linear zones of intensive dislocations with steep folds and overthrust is typical. The linearity of such dislocations and their rapid shift across their course by slanting layers leave no doubt as to their relations with zones of large-scale fractures. Essentially the whole post-Cambrian history of the western part of Tuva consists in the history of differential motion along the fractures of individual rocks, where the boundaries of separate big rocks and the amplitude of their sinking have determined the boundaries of accumulation basins, the depth of deposits, the intensity and direction of folding.

A good example of prolonged successive development of fractures and related directions of folded structures may be found in the regions of the Western Tannu-Ola Mountain Chain and in the territory north of Lake Ubsa-Nur (the Chadan-Khandaysk rock). In contrast to the northwestern directions and trends of the fold of the central parts of Cambrian geosynclines within the limits of the Western Tannu-Ola Mountain Chain, the latitudinal and west northwest directions are clearly marked. These directions, observed in all Paleozoic strata, are due to the slowly developing upheaval, started as early as at the end of Cambrian. A big island existed here during the upper Silurian; a peninsula existed during the Devonian; and an upheaval which closed the accumulation basin from the south occurred in the

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Carboniferous. A confirmation of the further development of latitudinal Cambrian fractures may be found in the contour of boundaries of the lower Devonian transgression, brought about by the sinking of the "Chadan-Khandaysk" rock. The sinking type of rocks of this region is confirmed by the relatively undisturbed layers of great thickness (down to 9 km) of Devonian-Carboniferous and by sharp reduction in thickness right beyond the boundaries of the territory of the above-mentioned rock, northwards and westwards (up to 1 km).

Since the end of the Paleozoic and the beginning of the Mesozoic the degree of difference in existing processes of the separated two zones of Tuva had been leveling off; and at the end of the Mesozoic the differently moving rocks came into a state of equilibrium and to a long relative rest. The whole country has been leveled by erosive processes and is approaching a "peneplain". During the Cenozoic era a stormy revival of rock movements occurred, shaking the whole territory of Tuva by the same amount. The youthfulness of these movements is confirmed, besides by numerous geomorphological facts and frequent earthquakes, by the intensity of the dislocation of Pliocene deposits. During this period old fractures were opened and new ones were started; but in both cases mostly latitudinal and, only in the extreme west, meridional fractures occurred.

Hence Tuva represents an extremely complicated region, and its tectonic structure may be named "folded-rock". Its contemporary structure is a result of a complex geological development, characterized by a long period of gradually increasing rate of crushing of big rocks into smaller ones with simultaneous differential movements relative to each other. The fact that we meet everywhere, in the contemporary Tuva highland, with the phenomena of tightly interwoven forms bearing the seal of deep antiquity together with recent features allows us to conclude that the topographical

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relief of this country is exceptionally recent and has appeared in the place of the ancient "peneplain" as a result of recent movements of rocks.

Presented 16 August 1950.

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(Key to Figures 1, 2, 3, 4.)

a- regions of probable dry land; b- Cambrian geosynclinal zone; c- Cambrian platform deposits; d- region of transgression in the upper Silurian; e- region of transgression in the lower Devonian; f- accumulation region of deposits D₂₊₃ and G; g- accumulation region of Permian marine deposits; h- accumulation region of Permian continental deposits; i- accumulation region of Jurassic fresh water deposits; k- regions of pre-Cambrian expansions; l- region of pre-Cambrian and lower Paleozoic expansion; m- region of mostly lower Paleozoic development; n- region of mostly middle and upper Paleozoic development; o- regions of mesozoic development of deposits; p- tectonic cavities, filled with tertiary and quaternary deposits; r- main directions of extensions of folding axes; s- fractures, observed and assumed.

UPHRAVALS. 1- East Sayan Mountain Range; 2- West Sayan Mountain Range; 3- Sangilen highland; 4- Bura Mountain Range; 5- West and East Tannu-Ola Mountain Ranges;

Depressions - regions of sinking; 6- Minusinsk; 7- Ulukhemsk; 8- Ubsanursk; 9- Terekhol'sk; 10- Arshansk; 11- Saldamsk; 12- Bus-Belinsk; 13- Serlig; 14- Todzhin; 15- Turan; 16- continuation (?) of Ulukhemsk valley.

[Note: Figures 1-4 follow on next page.]

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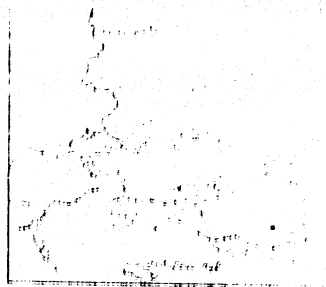


FIG. 1



FIG. 2

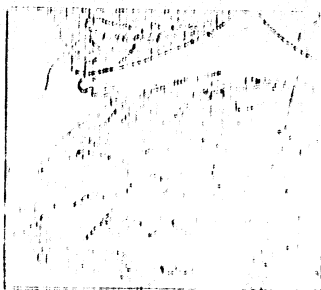


FIG. 3



FIG. 4

1. The first map (Figure 1) shows the location of the area of interest in the context of the surrounding region. The second map (Figure 2) shows the location of the area of interest in the context of the surrounding region. The third map (Figure 3) shows the location of the area of interest in the context of the surrounding region. The fourth map (Figure 4) shows the location of the area of interest in the context of the surrounding region.

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FIG. 1



FIG. 2



FIG. 3

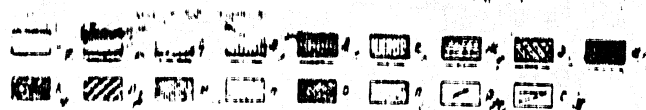
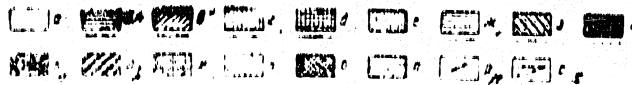
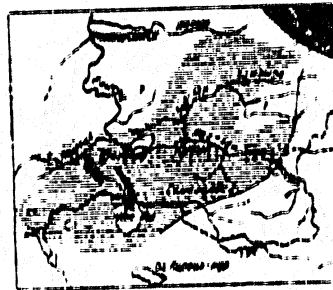
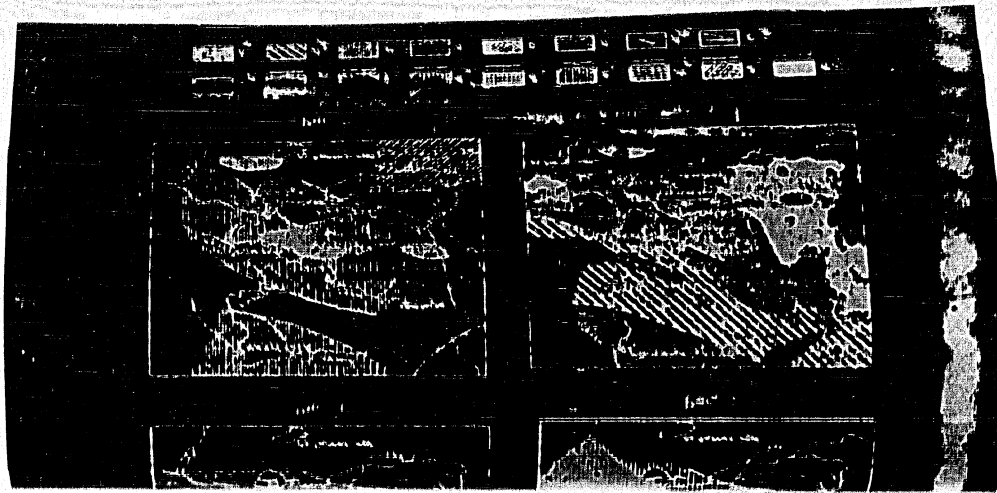
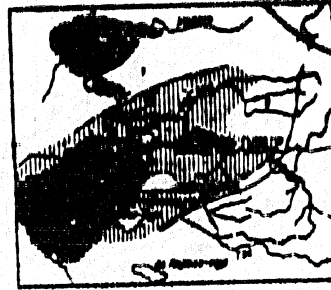


FIG. 4





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